geophysical institute, which is to deal with geodesy, tidal phenomena, seismology, and allied matters, has been approved, and a small committee is now formulating a definite scheme.

We notice the following among forthcoming books of science:—"Air Navigation Notes and Examples," Instructor-Capt. S. F. Card; "Tacheometer Tables," Prof. H. Louis and G. W. Caunt; "The Principles of Electrical Engineering and their Application," Prof. G. Kapp, vol. ii., Application (*Edward Arnold*); "The Pituitary," Blair Bell; "The Heart: Past and Present," Dr. E. Lea; "Injuries to the Head and Neck," Dr. H. Lawson Whale (*Baillière, Tindall, and Cox*); "The North Riding of Yorkshire," Capt. W. J. Weston; "Dumbartonshire," Dr. F. Mort, each in the Cambridge County Geographies Series (*Cambridge University Press*); "Economic Farm Buildings," E. P. Lawrence; "The Universal Wages Calculator," C. E. Lewton (*The Library Press, Ltd.*); "Kræpelin's Psychiatry," vol. iii., Dementia Præcox, translated by Dr. R. Mary Barclay, edited by Dr. G. M. Robertson; "A Handbook of Surgery (Civil)." C. R. Whittaker (*Edinburgh: E. and S. Livingstone*); "The Principles of Child Physiology, Pure and Applied," Dr. W. M. Feldman (*Longmans and Co.*).

OUR ASTRONOMICAL COLUMN.

Determination of Proper Motions.—In Circular No. 43 of the Union Observatory, Johannesburg, Mr. Innes publishes the result of an examination with the blink microscope of pairs of plates of eighty astrographic fields lent to him for the purpose by the Astronomer Royal, the plates of each pair being separated by an interval of nearly twenty years. The fields cover the zone of the sky from declination 65° to 67° N. through the whole twenty-four hours of right ascension, and out of the whole number of stars examined, estimated at 20,000, Mr. Innes has found nearly four hundred which have a measurable P.M., the large majority of which were previously unknown. The largest motions are 290″, 179″, and 167″ centennial on a Great circle. There are five between 50″ and 100″, sixty-seven between 20″ and 50″, and more than 300 less than 20″ centennial. Two hundred and fifty of the stars are in the Bonn Durchmüsterung, and are, therefore, of all magnitudes down to 9·5 or 10 visual, whilst the remainder are of photographic magnitude 10 to 12, with a few fainter. It will be realised that the motion of a star thus determined is relative to the stars in a limited area surrounding it, and not to the heavens as a whole. The systematic character of the figures in the table gives assurance that Mr. Innes's work forms a useful contribution to stellar statistics.

The Blink Microscope.—The fundamental principle of this instrument is somewhat obscured by its name. Having two similar photographs of the same field of stars taken at some interval of years apart, the obvious method of determining motion would be to superpose these plates with identical images fitting one on the other so far as possible, and then to search for those images which do not fit. As actual superposition is difficult, or impossible, for practical reasons, a method only slightly less simple is to adjust the plates side by side and measure the distances between identical images with a measuring bar. This is the principle of more than one type of instrument now being used to determine proper motion. In the blink microscope the images of the same star on the two plates are seen alternately by rapidly closing and opening shutters. Hence the name. Two images which fit fall on the same spot of the retina, but those of a star which has motion do not, and give the sensation of a jump. The method of detection is therefore simple, but it is clear that the measurement must be made with discretion lest errors occur because of imperfect adjustment or lack of exact similarity of the plates.

Calculation of Occultations of Stars by the Moon.—Mr. Arthur Snow publishes some tables for this purpose in *Popular Astronomy* for February, which should be of great use to those who do not live near one of the stations (Greenwich, Washington, etc.) for which special lists are available. He directs attention to the fact that the region of visibility of an occultation is a belt about half as wide as that for a total solar eclipse, crossing the parallels of latitude at a considerable angle, so that by no means all the places that lie between the published latitude limits enjoy a sight of the phenomenon. He gives full directions, which enable the limits of visibility to be laid down on a map.

X-RAYS AND BRITISH INDUSTRY.

The war has furthered the progress and development of many industries, but probably no department of science has received greater impetus than that of radiology, using the word in the general sense which it ought usefully to convey, and not in that restricted sense which the medical world has attached to it. The science and art of X-rays have developed enormously during the war, and nothing but good can result from the fact that the general medical practitioner has had his eyes opened to the vista which the X-rays have revealed. He now realises, as never before, that radiology is a new instrument of attack for him—a veritable handmaiden, whether he be physician or surgeon. The new diploma of radiology which Cambridge and other universities are about to establish is tacit recognition of the importance of X-rays in a medical curriculum. We welcome the suggestion that a chair of radiology should be established at one of the universities in memory of the late Sir James Mackenzie Davidson.

But it is not our purpose at the moment to dwell on the medical aspect of the rays. We are more concerned with a development to which the Germans, Americans, and ourselves have given considerable attention during the past year or more. We refer to the examination of materials and built-up structures by X-rays—a subject to which a joint meeting of the Röntgen and Faraday Societies in the meeting-room of the Royal Society devoted its attention on April 29.

It is a very far cry from the days of Röntgen's famous discovery some twenty-two years ago to the present time. The technique has advanced amazingly, but it can scarcely be said that apparatus and equipment have made corresponding strides, although it is, of course, not denied that considerable progress has been made. We refer to this point later, but the question is tied up with the attention the subject has received at the hands of the physicist and electrical engineer.

The meeting to which we have referred served admirably to set out the development and present limitations of the industrial uses of X-rays, and those of our readers who are interested may be referred for details of the meeting to the journals of the two societies concerned.

The great advantage of radiography is, of course, the fact that we can spy out the interior of an opaque body without injuring it in any way. Chief among the materials which have been examined by the X-rays is steel, both carbon and alloy. Naturally, the question of blow-holes and flaws in castings and forgings and ingots has received attention, and, provided that the thickness is not too great, the method works well. X-ray scrutiny has also suggested improvements in methods of casting and welding, as well as modifications in the composition of alloys, with a view to the surer production of sound castings.

Heavy alloy steels, such as tungsten steels, are, by reason of their greater opacity to X-rays, readily distinguishable from carbon steels. The method has also been applied, with, however, little or no success, to the detection of hair-cracks in steel castings. These cracks (which are of the order of 1/1000 in. across) have caused great trouble during the war in connection with the crank-shafts of aeroplane engines. The only way of attacking the problem would be to send the rays along the direction of the crack, but the difficulty is that these cracks refuse to confine themselves to one plane!

So far as the thickness of steel is concerned, several workers have taken radiographs through about 2 in. of steel, and this figure may be taken as the practical limit at the moment. Not that greater thicknesses have not been penetrated, but the exposure becomes intolerably long. In the case of aluminium and its alloys, thicknesses of 4 in. or 5 in. have been radiographed with ease. Incidentally, the method is very sensitive to minute differences in thickness—for example, the tool-marks used to face specimens are often clearly shown in radiographs of metals.

The voltages normally employed have ranged between 100,000 and 150,000 volts, and the currents through the tube from 4 to 15 milliamperes. The question of protecting the operator in this work needs particular attention.

In steel examination there is no possibility of using the fluorescent screen. Practically all workers have used photographic methods, and, furthermore, have been driven to adopt methods of reinforcing the image on the plate by the use of intensifying screens, metal-backing, or other devices. Pilon and Pearce have obtained good results with photographic films sensitised on both sides and sandwiched between two intensifying screens. They found it possible to determine a thickness of 1/10 mm. through 45 mm. of steel. All workers have found it important to cut out all extraneous radiation.

The X-ray method of examination is naturally very useful in examining explosive objects—for example, the details of the internal construction of torpedoes, shells, fuses, bombs, grenades, and cartridges. Aircraft construction demands both workmanship and material of the highest class, and a new grade of timber is now specified for this work of a quality such as has never been demanded previously. Knox and Kaye have turned the X-rays to account in inspecting aeroplane timber parts and plywood for faults which cannot be seen by ordinary visual examination. Concealed knots or gum-pockets, bad gluing, or poor workmanship are readily revealed. Only soft rays are necessary, and the great transparency of wood permits fluorescent-screen examination—a necessity for routine inspection—and allows any thickness likely to occur in practice to be radiographed readily.

The motor manufacturer has radiographed carburettors and magnetos while in operation, and so has been enabled to detect elusive faults. The Hadfield Research Laboratory, which has done much work on radio-steel examination, has extended the method to the scrutiny of carbon electrodes for electric steel furnaces. The Post Office has used the rays for testing the amount of mineral matter in gutta-percha. Woolwich Arsenal has also used the method. Radiography would doubtless prove to be a convenient means of detecting hidden corrosion in metals—for example, in gas cylinders, in ferro-concrete, or in the armouring of cables. Mention should be made of the coming importance of stereoscopic radiography.

There is one other and entirely different way in which X-rays may supplement the radiographic method of examining material. Prof. W. H. Bragg, to whom the subject owes so much, has shown that the X-rays enable us to examine in detail the nature and extent of the crystallisation of a body. Now it appears to be the case that there is little in Nature which is not crystalline to a greater or less degree, and, further, it is certain that crystalline structure is of first importance in determining the quality of certain substances such as steel. A large field of research is here indicated.

We do not anticipate any startling developments in the use of X-rays for the examination of steel until the present apparatus for generating X-rays has been vastly improved. We are led to inquire what part this country has played in the past in the development of either the high-potential generator or the X-ray tube. The answer is not very gratifying. The British generator is almost always an induction coil of which the present-day model differs but little in essentials from its predecessor of Spottiswoode's day, except that it is capable of a "fatter" spark and greater output generally. It breaks down less frequently owing to closer attention to the insulation of both primary and secondary coils. But what of design? How many British coil-makers employ a designer who can honestly say that he is not working mostly empirically, by trial and error, by "hit and miss," or whatever you like to call it? The fact is, the man who could do things any other way—by reasoned calculation and experiment—has so far not had it made worth his while to work at the subject. Moreover, how and where are men to be trained in the groundwork of the subject? In how many university physical or electrotechnical laboratories does the matter receive even the smallest attention?

What would prove to be the result of reasoned investigatory work on the induction coil? Compared with other types of high-tension transformer the present-day induction coil is not efficient, and the chances are that it never will be. At any rate, our American cousins have come to that conclusion, and are concentrating on closed-circuit, interrupterless transformers which can operate with any commercial A.C. supply, and are generally used in conjunction with some type of hot-cathode "rectifier" to suppress the "inverse" phase of potential. The British answer has mostly been to point out that the sinusoidal potential wave is not so efficient an X-ray producer as the peaked wave of an induction coil. Of the degree of practical importance of this difference we have no experimental knowledge. It is probably on a par with the oft-repeated, but untrue, statement that a Coolidge tube is not so good as an ordinary gas tube for securing first-class radiographs.

This leads us to the question of the X-ray tube. Its present efficiency is of the order of 1/1000. We are led to inquire in what outstanding points has the British tube made progress since Sir Herbert Jackson's introduction of the concave cathode in 1897—itself identical with one used by the late Sir William Crookes some twenty years previously. Again, has the British tube ever been superior to either the German or American? We know the answer most radiographers would give us. Before the war we could not even make the glass for the bulb. But that is another story. From the point of view of the Old Country, it is a regrettable fact that it should have been left to America to develop (in the shape of the Coolidge tube) pioneer research work done by

Englishmen. The latest model of the Coolidge tube acts efficiently as its own rectifier, and the high-tension outfit is correspondingly simplified.

In simple justice one must add that the scientific energies of this country have been far more distracted and dislocated by the war than have those of America. But the Department of Scientific and Industrial Research ought to have no hesitation in adding to the list of investigations it has tackled during and since the war.

To return to the question of future developments of the X-ray scrutiny of metals. The question of the light alloys is relatively simple, but for the heavier metals we need photographic plates and fluorescent screens of much higher efficiency. In addition, we need a method of generating X-rays in far greater abundance and of far greater hardness (*i.e.* shorter wave-length) than we have at present. In this connection every investigator and user ought to develop the habit of precise measurement of both current through the tube and, more important, the potential difference across the terminals. The voltage is commonly left to be inferred as well as may be from the alternative spark-gap between electrodes the size and shape of which are rarely mentioned. Or, more frequently, the hardness of the rays is given in some arbitrary unit difficult to define or reproduce. But radiology generally rejoices in a wealth of indefinite units and measuring instruments, mostly introduced by workers who had enthusiasm but little physics. The subject of practical radiology has, unfortunately, been severely ignored by the physicist and the electrical engineer. Their assistance in this matter is earnestly needed both by the medical man and by the workers in this new field of the application of X-rays to the examination of materials. The Röntgen Society has on its roll of members most of the younger X-ray physicists in the country, and we suggest that it should take early steps to co-ordinate the unrivalled experience and equipment of its physical and medical members for the ultimate benefit of British industry.

G. W. C. KAYE.

RADIO-TELEGRAPHIC INVESTIGATIONS IN CONNECTION WITH THE SOLAR ECLIPSE OF MAY 29, 1919.

It will be remembered that in a letter to NATURE of February 13 last Sir Oliver Lodge, chairman of the British Association Committee for Radio-telegraphic Investigation, explained that his committee did not contemplate taking a very active part in organising wireless observations during the forthcoming solar eclipse, and hoped that parties travelling to the eclipse zone for the observation of astronomical, meteorological, and magnetic phenomena might be able to make wireless telegraph observations also. Later it was found that the various parties charged with the other observations would be too fully occupied to give any attention at all to wireless telegraphy, and therefore the committee has arranged for the carrying out of the experiments to be described below.

The umbra intersects the earth's surface in an approximate circle of diameter of about 234 km. (126 sea-miles), and it moves at the slowest at a speed of about 0·57 km. (0·31 sea-mile) per second. Between 11.30 and 12 (Greenwich mean time) it travels across Bolivia and Brazil, and crosses the Atlantic close to the equator between 12 and 14.20. It then crosses the African continent from the French Congo to Mozambique. During the eclipse various wireless telegraph stations will emit signals consisting of letters of the alphabet changed according to a definite plan at the end of each minute; the programme of letters is so arranged that no two come together in the same order more than once. They will be accurately timed at selected receiving stations. By this arrangement the transmitting stations are relieved of the responsibility of timing the signals accurately, and the receiving operators have nothing to do but to write down each letter as they receive it and the number denoting its strength on the scale (0 to 9) familiar to all wireless telegraphists. On the day before the eclipse the stations will send practice signals for a short time near noon (G.M.T.).

The British Admiralty stations at Ascension and the Azores will send continuously during the transit of the umbra across the Atlantic Ocean. Observing stations north of the equator will, for the most part, be asked to listen to Ascension for at least an hour round about the time when the umbra passes between themselves and Ascension. Similarly, observers south of the equator will be asked for the most part to listen to the Azores. Certain selected stations north of the equator will be asked to listen to the Azores so as to afford check observations upon the variations that may be observed in signals passing across the central line of the eclipse, and similarly selected stations south of the central line will be asked to listen to Ascension. The great American station at Annapolis may also transmit a programme during a portion of the period of the eclipse, and it is hoped that arrangements may be made for special experiments between a few pairs of stations, such as Darien and the Falkland Islands, and an Egyptian station and a South African station.

The main portion of the experiment hinges upon Ascension. The umbral cone passes from west to east, and may be expected to affect in succession the strength in which signals are received at such stations as Demerara, Jamaica, the stations on the coast of the United States and Canada, and stations in Ireland, England, France, Italy, the Mediterranean, and Egypt.

It is by the kindness of the American Government and of our own Admiralty that the stations at Darien and Annapolis, and at Ascension and in the Azores, are being used for the sending of the experimental waves. The Admiralty has, besides, provided many of the receiving stations both on land and sea, and other receiving stations are being put to work by the American, French, and Italian Governments, by our own Army and Air Force and also by the Marconi Co. in several parts of the globe.

The observers' results will be collated with the view of finding if the passage of the shadow cone between a sending and a receiving station causes any regular change in the strength of signals. According to some writers, the propagation of waves over long distances is greatly affected by the ionisation of the upper atmosphere. During a solar eclipse the cone of densest shadow removes all sunlight from the atmosphere within it, which may stop the ionising actions of sunlight and allow the recombination of separated ions to take place. This process starts in the penumbra, but it is accomplished fully, or to its fullest extent, only in the umbra. Thus at any particular fixed place in the air the penumbra, it is thought, first starts a gentle recombination of ions, and as the eclipse at that place progresses and darkness increases, recombination of ions takes place more and more quickly until the time of complete totality. Afterwards the onward passage of the umbral cone allows sunlight to begin again its ionising action. Something of this kind is, at any rate, supposed to be taking place at sunset and sunrise every day, and to be the main cause of the enormous variations experienced in signal strengths at those times.

It is sometimes supposed that the electric waves carrying signals take a curved trajectory in the atmo-